Title: A CONTINUOUS PROCESS FOR MAKING AN AQUEOUS HYDROCARBON FUEL EMULSION

This is a continuation in part of U.S. Application No. 09/731,173 filed December 6, 2000, which is a continuation in part of 09/483,481 filed January 14, 2000, which is a continuation in part of U.S. Application No. 09/390,925 filed September 7, 1999, which is a continuation in part of U.S. Application No. 09/349,268 filed July 7, 1999, and which is a continuation in part of No. 09/761,482 filed January 16, 2001, which is a continuation of No. 09/755,577 filed January 5, 2001. All of the disclosures in the prior applications are incorporated herein by reference in their entirety.

Technical Field

The invention relates to a process for making aqueous hydrocarbon fuel emulsions from a continuous or batch process with good stability. More particularly, the invention relates to a process for making an aqueous hydrocarbon fuel emulsion by employing an initial emulsion as one of the reactants in the process.

Background of the Invention

Internal combustion engines, especially diesel engines, that employ water mixed with the fuel in the combustion chamber can produce lower nitrogen oxides (NOx), hydrocarbons and particulate emissions per unit of power output. The reduction of nitrogen oxides is an environmental issue because they contribute to smog and air pollution. Governmental regulations and environmental concerns have driven the need to reduce NOx emissions from engines.

Diesel-fueled engines produce NOx due to the relatively high flame temperatures reached during combustion. The reduction of NOx production conventionally includes the use of catalytic converters, using "clean" fuels, recirculation of exhaust and engine timing changes. These methods are typically expensive or complicated to be readily commercially available.

Water is inert toward combustion, but lowers the peak combustion temperature resulting in reduced particulates and NOx formation. When water is added to the fuel it forms an emulsion and these emulsions are generally unstable. Stable water in fuel emulsions of small particle size is difficult to reach and maintain.

Stable water in fuel macroemulsions of small particles size are difficult to make. It would be advantageous to develop a process to make water in fuel

macroemulsions in which a batch process did not need a statistical number of tank turnovers to produce a 1.0 micron or less water in fuel emulsion. Further, it would be advantageous to produce submicron mean average particles in a water in fuel macroemulsion by a continuous process.

It has been found that including an emulsion as an initial component with the water fuel and emulsifier in a batch or continuous process produces an improved stable water in fuel macroemulsion with a mean average particle size distribution of 1 micron or less.

The term "NOx" is used herein to refer to any of the nitrogen oxides, NO, NO_2, N_2O, or mixtures of two or more thereof. The terms "aqueous hydrocarbon fuel emulsion" and "water fuel emulsion" are interchangeable. The terms "aqueous hydrocarbon fuel" and "water fuel blend" are interchangeable.

Summary of the Invention

The invention relates to a batch or continuous process for making an aqueous hydrocarbon fuel emulsion comprising: emulsifying (a) a liquid hydrocarbon fuel, water and at least one emulsifier, (b) a reactant emulsion of the liquid hydrocarbon fuel, water and at least one emulsifier, and (c) water, under emulsification conditions to form an aqueous hydrocarbon fuel emulsion.

The aqueous hydrocarbon fuel is an emulsion comprised of water, fuel and an emulsifier. The emulsifier comprises:

(i) at least one fuel-soluble product made by reacting at least one hydrocarbyl-substituted carboxylic acid acylating agent with ammonia or an amine, the hydrocarbyl substituent of said acylating agent having about 50 to about 500 carbon atoms;

(ii) at least one of an ionic or a nonionic compound having a hydrophilic-lipophilic balance (HLB) of about 1 to about 40;

(iii) a mixture of (ii) with (i);

(iv) a water-soluble compound selected from the group consisting of amine salts, ammonium salts, azide compounds, nitrate esters, nitramine, nitrocompounds, alkali metal salts, alkaline earth metal salts, in combination with (i), (ii), (iii), (v), (vii) or combinations thereof;

(v) the reaction product of polyacidic polymer with at least one fuel soluble product made by reacting at least one hydrocarbyl-substituted carboxylic acid

acylating agent with ammonia, an amine, a polyamine, alkanol amine, or hydroxy amines;

(vi) an amino alkylphenol which is made by reacting an alkylphenol, an aldehyde and an amine resulting in an amino alkylphenol, or

(vii) the combination of (vi) with (i), (ii), (iii), (iv), (v) or combinations thereof.

The aqueous hydrocarbon fuel emulsion includes a discontinuous aqueous phase in a continuous fuel phase. The discontinuous aqueous phase comprises aqueous droplets having a mean diameter of 1.0 micron or less. Furthermore, the use of an emulsion as an initial component in the batch or continuous process has improved the efficiency of the process and the stability of aqueous hydrocarbon emulsions for use as aqueous hydrocarbon fuel emulsion.

The Process

The invention provides for a batch or continuous process for making an aqueous hydrocarbon fuel by forming a stable emulsion in which the water is suspended in a continuous phase of fuel and wherein the water droplets have a mean diameter of 1.0 micron or less. The droplet size is in volume.

In the practice of the present invention the aqueous hydrocarbon fuel emulsion is made by a batch or a continuous process capable of monitoring and adjusting the flow rates of the reactant emulsion, fuel, emulsifier, additives and/or water to form a stable emulsion with the desired water droplet size.

The batch process as described herein depicts one embodiment of the invention. The hydrocarbon fuel, emulsifier, and reactant emulsion are added to a vessel. The water is added to the vessel or, in the alternative is added close to the entry portal of the emulsification device, which is external to the vessel. In the batch process the following components are emulsified:

(1) about 10% to about 90% by weight of the fuel and about at least 0.1% to about 25% by weight of emulsifier,

(2) about 1% to about 90% by weight of a reactant emulsion, and

(3) about 1% to about 50% by weight of water, wherein the water contains about 0% to about 30% by weight of the aqueous hydrocarbon emulsion.

The ratio of fuel, water and emulsifier to reactant emulsion is about 1 to about 99, in another embodiment about 15 to about 85, in another embodiment about 40 to about 60, in another embodiment about 99 to about 1, in another embodiment about